Fire Protection Assessment / Fire Hazard Analysis

NASA Space Radiation Laboratory – Buildings 756,757,758 & BAF Tunnel
Brookhaven National Laboratory

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Date of Survey: **February 13, 2004**
Date of Report: **March 29, 2004**

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FHA - NASA Space Radiation Laboratory

PURPOSE/SCOPE

The purpose of this assessment is to comprehensively and qualitatively assess the risk from fire within NASA Space Radiation Laboratory to ensure DOE fire safety objectives are met. DOE fire protection criteria are outlined in DOE Order 420.1[1], Chapter 4. The fire protection assessment includes identifying the risks from fire and related hazards (direct flame impingement, hot gases, smoke migration, fire-fighting water damage, etc.). A Fire Hazard Analysis (FHA), required for the Safety Analysis Document for the NSRL, is incorporated into this assessment.

SUMMARY:

The planned use of the NASA Space Radiation Laboratory is described in the "Occupancy and Associated Fire Hazards", section below. These descriptions are based on field surveys, a review of the planned and completed installations, and discussions with NSRL staff. This assessment and FHA demonstrates the achievement of a reasonable and equivalent level of fire safety that meets DOE improved risk objectives.

RECOMMENDATIONS:

1. On the exterior wall of the NSRL Support Building 958 separate the gas cylinder storage area and the propane gas cylinder by 20 feet or more.

2. Create a smoke rated wall and door assembly between the Target Room (9560 and the Support building (958). The existing wall and door is not in violation of the codes of record, nor are they in violation with current codes for existing buildings. However if the buildings were required to meet current codes by either an occupancy or egress change or a major renovation to either area a 1 hour rated separation between to two areas would be required for occupancy separation. The smoke rated wall and door is not intended to meet the requirements of a 1 hour rated separation, but would be considered good engineering practice. The concern is the possibility of smoke migration from the non-sprinklered Target Area to the sprinklered Support building. Smoke damage could result the loss of experiment samples and equipment and the loss of time to clean the Support building.

3. Vital Record backup procedures should be verified for the vital records being generated by the experiments to make sure it conforms to BNL standards.

4. The Support Building (958) and the Power supply Building (957) should be outfitted with lightning protection systems to minimize the potential of lightning damage. NFPA recommends installation of the system based on a set of calculations based on building configuration height and proximity of other structures/trees within a distance of 3 times the height of the buildings. In both cases these buildings were evaluated and determined that a lightning protection system would be required.

[1]US Department of Energy Order No. 420.1, Facility Safety, 11/16/95

ANALYSIS:

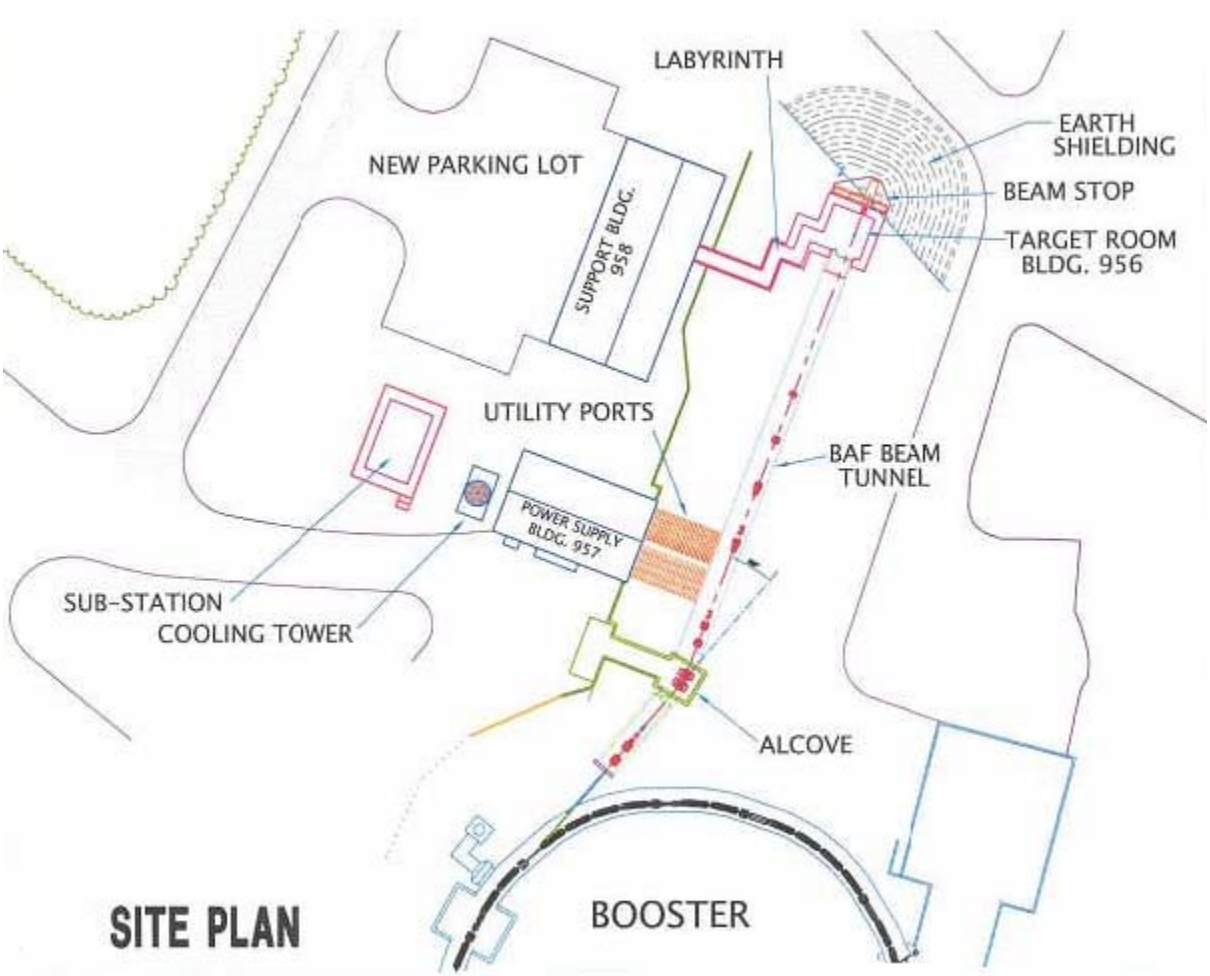
2 SCOPE

The assessment and analysis of the NASA Space Radiation Laboratory is divided into four areas: The Support Building (958), The Target Room (956), Booster Applications Facility (BAF) Tunnel, and Power Supply Building (957).
This assessment and FHA are based on information supplied by the NSRL staff, a review of the facility, and a review of construction drawings and specifications.

3 LOCATION

The NASA Space Radiation Laboratory is located in the central west region of Brookhaven National Laboratory (BNL). BNL is a 5,000 acre site owned by the Department of Energy and operated by Brookhaven Science Associates. BNL is located in Upton, New York.

FHA - NASA Space Radiation Laboratory



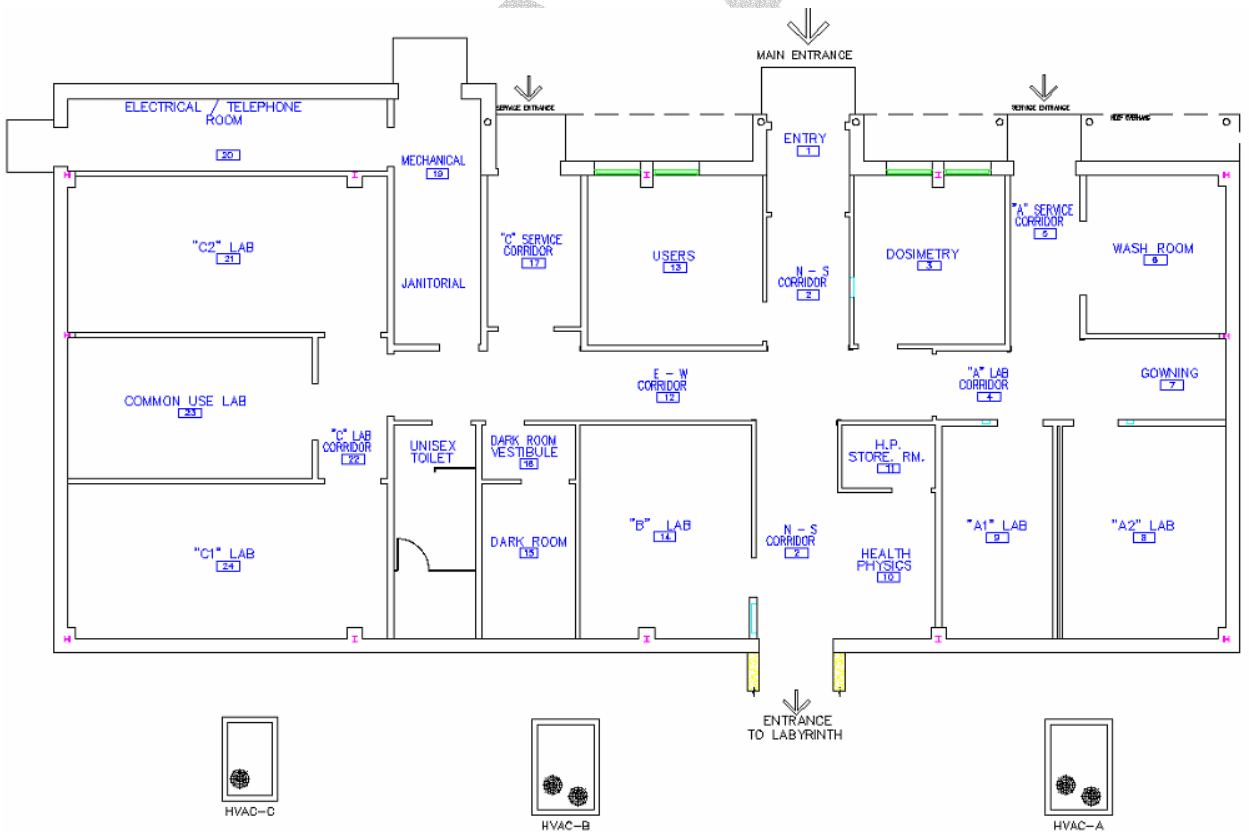
4 CONSTRUCTION

4.1 NSRL Support Building (958)

The NSRL Support Building is used for cell and animal target preparation and assessment. The cell preparation laboratories will store and prepare cell cultures. Animal study rooms will house and prepare animals.

The Support Building is a one story high pre-engineered structure, with floor dimensions of 100 ft. by 40 ft (interior dimensions). The building is 18 feet high. The building exterior walls are masonry for the first few feet and then constructed of insulated metal panels on steel frames for the remaining height. The roof is a sloped insulated metal roof with fiberglass insulation added beneath. The walls and roof assembles are considered to be equivalent to non-combustible construction. The foundation is poured concrete. Interior walls are concrete block or gypsum board on metal stud. Non-combustible suspended ceiling is being provided. Walls do not go beyond the hung ceilings. There are no interior fire barriers.

Three HVAC zones exist for the building. HVAC zone “A” covers the “A” Lab Area of the building. HVAC zone “B” covers the middle or “B” Lab Area of the building. HVAC zone “C” covers the “C” Lab Area of the building. The Air Handling Units for the HVAC systems are located outside on the east side of the building.



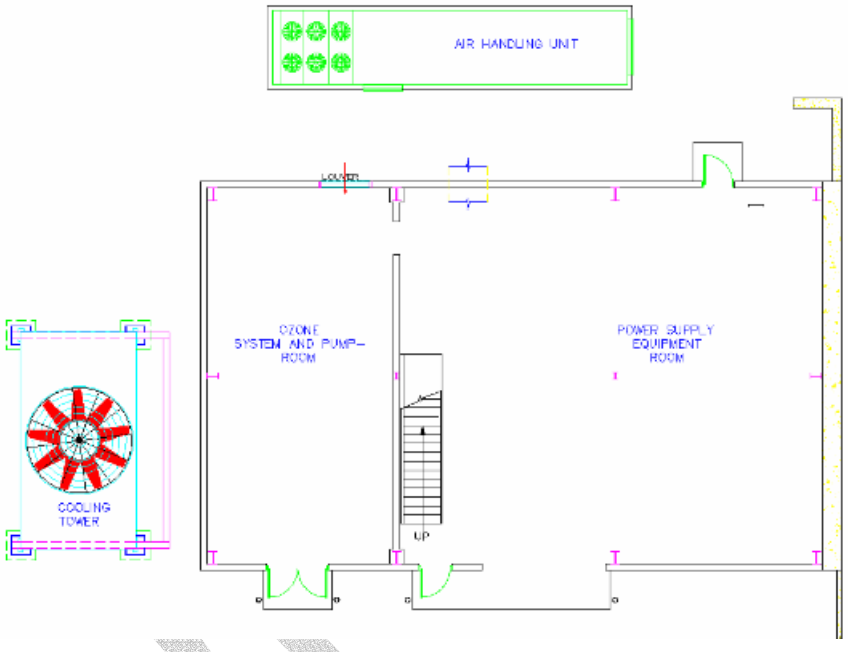
4.2 Power Supply Building (957)

The building is 65 ft. by 40 ft. (interior dimensions) with a concrete slab floor. The Power Supply Building is a two-story high building constructed of non-combustible pre-engineered insulated metal walls and roof. The building is 27 feet high. The second floor has been created by the installation of a metal mezzanine. The mezzanine floor is an open grate construction.

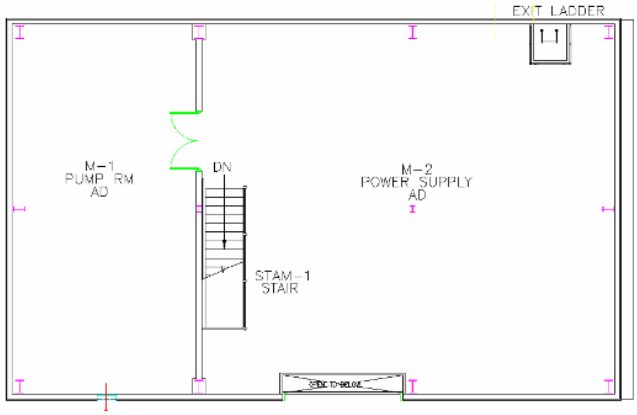
One HVAC zone exists for the building. The Air Handling Unit for the HVAC system is located outside on the north side of the building.

A metal cooling tower is installed 6 feet to the west of the Power Supply Building. The structure is non combustible construction but has combustible water fill elements.

An electric substation is located 20 feet to the west of the cooling tower. The 1500 kVa and 2000 kVa electrical transformers and switch gear are arranged to meet the recommendations in Factory Mutual Loss Prevention Data Sheet 5-4 for fire protection.



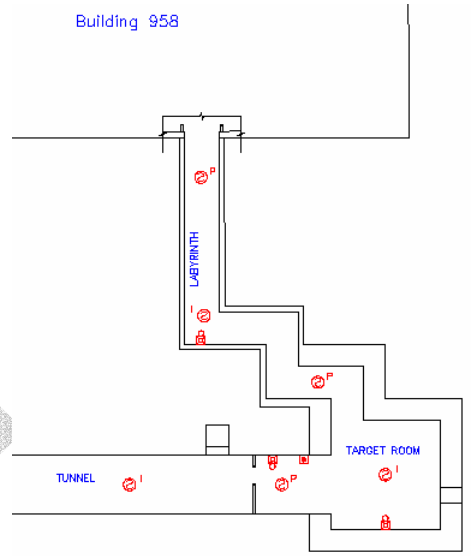
Ground Level



Mezzanine Level

4.3 NSRL Target Room (956)

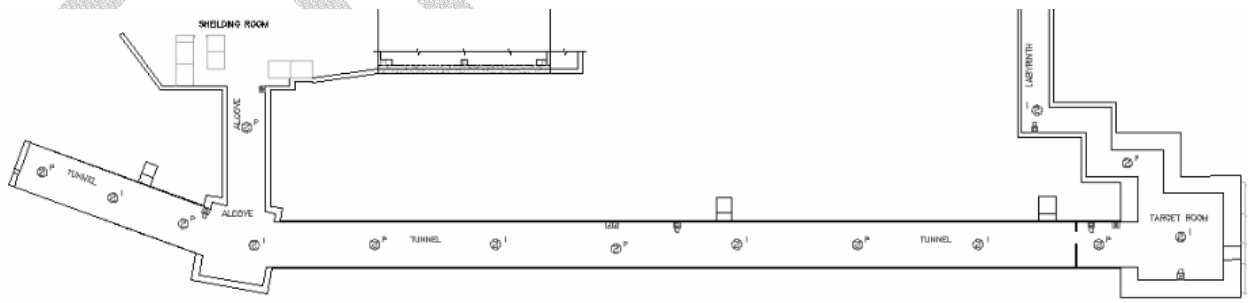
The Target Room is a 20 ft. by 20 ft. by 10 ft. high (interior dimensions) poured concrete room. The flame spread rating of the finish is considered to meet ASTM E-84 Class A rating. The room is located under ground and is connected to the NSRL Support Building by a poured concrete labyrinth on the west side. The Target Room connects to the tunnel on the south side. The accelerator beam line enters through the tunnel opening. A radiation security gate and door separate the Target Room from the Tunnel. The structure is windowless and does not contain interior fire barriers.



4.4 Booster Applications Facility (BAF) Tunnel

The tunnel is constructed from a corrugated metal tube, 11 ft. in diameter. Concrete flooring is provided. The flame spread rating of the finish is considered to meet ASTM E-84 Class A rating. The tunnel is located underneath approximately 15 ft. of earth (for radiation shielding). The structure is windowless and does not contain interior fire barriers. The tunnel has a emergency smoke removal system located mid span of the tunnel. The emergency smoke removal system consists of one 17,000 CFM exhaust fan on emergency power. The tunnel connects to the NSRL target room on the north and has an exterior access way to a parking area on the south east.

One HVAC zone exists for the tunnel. The Air Handling Unit for the HVAC system is located outside on the east side of the tunnel between the Support Building and the Power Supply Building.



5 FIRE PROTECTION

Existing Fire protection systems that provided protection to full or segmented portions of this facility can be classified in four categories; Automatic Fire Suppression Systems, Fire Alarm, Automatic Detection Systems, and Fire Extinguishers. The following is a description of each category.

5.1 Automatic Fire Suppression Systems

Automatic Fire Suppression Systems consisting of Sprinkler, Standpipe, and Detection Systems are provided in this facility. Sprinkler and Standpipe systems are supplied by the Site Water System via the Building Water Supply and Fire Department Connection. A description of each of these systems and the area they protect is outlined below.

5.1.1 Site Water System

BNL has a combination domestic and fire protection water supply system. The system is supplied by several deep wells and is stabilized by two elevated water storage tanks (one 1 million gallon and 303,000 gallon capacity). The wells have electric primary drivers and a limited number have backup internal combustion drivers. The system can sustain three days of domestic supply and a maximum fire demand (4,000 GPM for 4 hours) for BNL with two of the system's largest pumps out and one storage tank unavailable. The piping distribution network is well gridded. The distribution system in the area of the NASA Space Radiation Laboratory has a static supply pressure of 68 PSI. The combination domestic and fire water supply system can supply 3850 GPM at 20 PSI (based on test results from a summer 2003 test).

Fire hydrants are provided within 300 ft. of each facility. Frost proof hydrants are needed since the frost line extends to 4 feet below the surface in the winter. BNL and the local Suffolk County Fire Departments use National Standard Thread couplings.

BNL's Plant Engineering Division maintains the water supply system. BNL's Fire/Rescue Group conducts valve inspections on the distribution system to ensure reliability of firefighting water supplies.

5.1.2 Building Water Supply, and Fire Department Connection

Support Building (958) has a single 4 inch black steel main connected to an 8 inch main located along West 5th Street. The main has a 4 inch Post Indicating Valve (PIV) located more than 40 feet from the building. The PIV is a gate valve type valve. The PIV has an electric tamper switch. The main and the PIV were installed when the building was constructed.

The main enters the Support Building on the west side of the building into the Mechanical on the first floor. The room has an exterior door which cannot be used for Fire Department access since it does not have key mechanism on the exterior door lockset. The 4 inch main is utilized by both the domestic water system and the fire protection systems. The two services split outside of the building the 4 inch fire protection piping continues to the Alarm Check Valve Assembly. This configuration does not meet the current BCNYS requirement of a double check valve on the fire protection system to prevent contamination to the potable water supply.

A Fire Department Connection (FDC) is located on the west side exterior wall of the Support Building adjacent to the mechanical room exterior door. The nearest hydrant is less than 400 feet from the fire department connection as required by code. The two 2 ½ inch outlets on the FDC conform to National Standard Thread couplings standards. The piping between the Fire Department Connection and the supply side of the Alarm Check Valve Assembly is 4 inch. The pipe connects to the discharge side of the Alarm Check Valve.

5.1.3 Sprinkler Systems

The Target Room (956), Booster Applications Facility (BAF) Tunnel, and Power Supply Building (957) are not provided with an automatic sprinkler system. They are not required to be fully sprinklered since they do not exceed the criteria set forth by the "*Implementation Guide For The Use With DOE Orders 420.1 and 440.1 Fire Safety Program*," section 9.7 which requires fully sprinklered protection in any building exceeding 5,000 square feet in ground floor area or any facility with a Maximum Possible Fire Loss exceeding $1 million. The limited combustible loading and maximum possible fire loss potential of less than $1 million dollars do not warrant a dedicated fire protection system for these building.

In the Support Building (958) Automatic sprinkler system protection, conforming to NFPA 13 is provided throughout the building. There is one sprinkler system zone.

5.1.3.1 Alarm Check Assembly

A 4 inch Reliable model 4E Alarm Check Valve assembly is located in the Mechanical room of the Support Building (958). It is U/L and FM listed. The alarm check has a water motor gong that is placed on the exterior of the building per the requirements of NFPA. On the discharge side of the alarm check valve is a water flow switch which provides the required alarm signals for flow activation to the building fire alarm panel.

5.1.3.2 Wet Pipe Sprinkler Systems

The wet pipe sprinkler system in the Support Building is hydraulically sized to provide 0.15 GPM per square foot sprinkler density over 2500 sq. ft. of the most hydraulically remote area of the building. The sprinkler heads are spaced to ordinary hazard requirement of NFPA 13. Total inside and outside hose requirement of 250 GPM for ordinary hazard was added to the calculations. The system requires 925 GPM at 43 PSI at the building enterence. Available water supply meets the water supply requirements for the hydraulically calculated sprinkler systems

5.1.4 Fire Standpipe Systems

The Target Room (956), Booster Applications Facility (BAF) Tunnel, and Power Supply Building (957) are not provided with an Fire Standpipe system. They are not required by code to be provided with Fire Standpipe systems.

An automatic wet standpipe system conforming to NFPA 14 is installed in the NSRL Support Building. The class of standpipe system, as listed in the BCNYS, is "Class III"

system. The hose valves are located in hose cabinets in the corridor outside of the “B” Lab Room. The standpipe system is connected to the automatic sprinkler system.

5.2 Fire Alarm Systems

The facility has a fire alarm system that is connected to the Site fire Alarm system. The two systems are as follows.

5.2.1 Building Fire Alarm System

The NSRL Support Building has a building fire alarm system consisting of a fire alarm panel, manual stations, and visual and audio alarm notification devices conforming to NFPA 72. The fire alarm panel is located in electrical room on the south-west side of the building. The fire alarm panel is a Grinnell Multi-zone 20 (panel 213). This panel provides supervision for all the buildings and tunnels of the NSRL Facility. The panel is connected to the Site Fire Alarm System via the copper wire in the site underground telecommunication infrastructure network.

5.2.2 Site Fire Alarm System

Brookhaven National Laboratory provides central fire alarm station coverage by an Underwriter Laboratory listed multiplexed Site Fire Alarm System. The system is a Wormald System 1000; installed in 1987 (Wormald is now known as Grinnell Fire System). The system complies with the requirements of NFPA 72 for a Style 7D System.

The system uses the existing site telephone cable plant. RS232 signals are sent via full duplex line drivers. Each fire alarm panel has two channels connected to the Central Station. The panels are divided into 7 communication "loops." The system can monitor more than 20,000 points. It is currently monitoring 3,800. Response time from alarm at the panel to alarm indication at the Central Station is less than 10 seconds, which is well within the 90 seconds allowed by NFPA 72.

The main console is at the Firehouse, Bldg. 599. This station monitors all fire alarm signals, trouble and communication status alarms. A satellite station is provided at Safeguards and Security, Bldg. 50, and receives only the fire alarm signals. If the Firehouse does not acknowledge an alarm within 90 seconds, the satellite station at Bldg. 50 will receive an audible indication to handle the alarm. A second satellite station is provided at AGS Main Control Room, Bldg. 911, and receives only the fire alarm signals from the RHIC/AGS accelerator buildings. A team of operators and Health Physics Support personnel respond during accelerator operating times.

5.3 Automatic Detection Systems

Automatic detection systems are used in this facility. Areas protected are noted in the following table.

Location	Building	Detector Type(s)	Connected To	Coverage Type	Spacing Complies to NFPA 72
Dosimetry Rm.	958	P, I	Bldg 958 FAP	Room	Yes
'B" Lab Rm.	958	P, I	Bldg 958 FAP	Room	Yes
Main Supply Air Duct(s)	958	P	Bldg 958 FAP	Duct	Yes
Target Rm. & Labyrinth	956	P, I	Bldg 958 FAP	Entire Space	Yes
BAF Tunnel & Alcove	Tunnel	P, I	Bldg 958 FAP	Entire Space	Yes
Power Supply Bldg.	957	P, I	Bldg 958 FAP	Ground & Mezzanine	Yes
Main Supply Air Duct	957	P	Bldg 958 FAP	Duct	Yes

Symbols-

F: Fixed Temperature Heat Detectors
FAP: Fire Alarm Panel
I: Ionization Smoke Detectors
P: Photoelectric Smoke Detectors
R: Rate of Rise Heat Detectors

5.4 Fire Extinguishers

Fire extinguishers installed throughout the facilities are in accordance with NFPA 10.

6 FIRE HAZARDS

Fire hazard potentials are classified into four major categories; Building Materials, Special Occupancies, Exterior Hazard Exposure, and Natural Hazard Exposure. The following is an evaluation for each category.

6.1 Special Occupancies

Special occupancies include: electronic data processing, vital and important records, trailers, cooling towers, electrical substations, flammable liquid and gas storage, cables and raceways, . The special occupancies of NSRL are expanded upon in sections 5.1.1 and 5.1.7, below.

6.1.1 Electronic Data Processing

The Dosimetry Room, located in the Support Building, contains high valued electronics for measuring delivered dose to the target organisms. The “B” Lab Room, also located in the Service Building, contains high valued electronics for data collection. Bldg. 958 is fully sprinklered and the Dosimetry Room and “B” Lab Room have early warning smoke detectors. With early warning smoke detectors and the presence of facility sprinkler protection, the electronic data processing areas are suitable for equipment values over $25 million dollars. Total values of each area are under $1 million dollars

6.1.2 Vital and Important Records Storage

Vital records are those records which are essential to the mission of an important program and which, if lost, could not be reproduced or obtained elsewhere. Important records are those records possessing a high value to the mission of an important program but which, if lost, could be reproduced or reconstructed with difficulty or extra expense.

Based on the above definitions, the data collected from the experiments are considered vital records. Review of the backup procedure of data collected as part of this program is out of scope of this Fire Hazard analysis but will be a recommendation to ensure it is being adequately protected in accordance with DOE requirements (recommendation #3).

6.1.3 Trailers

There are no trailers associated with NSRL.

6.1.4 Cooling Towers

The unit is metal, prefabricated, and serves the BAF magnet cooling water system, and the power supply/buss cooling system. A fire in the cooling tower will not cause damage to the main buildings due to spatial separation and the limited amount of combustibles in the tower

6.1.5 Electrical Substations

The 1500 kVa and 2000 kVa electrical transformers and switch gear are arranged to meet the recommendations in Factory Mutual Loss Prevention Data Sheet 5-4 for fire protection. The transformers do not present an exposure hazard to the facility or each other.

6.1.6 Flammable Liquid & Gas Storage

The use of flammable liquids in the NSRL is minimal. The anticipated use of solvents will be less that 1 quart in each laboratory space. Use of flammable liquids will follow BNL ES&H Standards (found at https://sbms.bnl.gov/ld/ld08/ld08d481.pdf).

The only use of a flammable gas will be for Bunsen burners in the lab spaces in the NSRL Support Building. Propane gas is distributed through a fixed piping system. The propane storage tank is located on outside of the south exterior wall less than 20 feet to the Gas Cylinder Storage Area (recommendation #1). The use of all flammable gases follows BNL Standards (found at https://sbms.bnl.gov/ld/ld08/ld08d491.pdf).

6.1.7 Cables and Raceways

High voltage, low voltage, control, and signaling cables are to be segregated in accordance with NEC requirements throughout the NASA Space Radiation Laboratory. The cabling is located in conduits, raceways and cable trays. In most instances, the cables provided in the cable trays meet the flammability test criteria in IEEE 383, VW-1, and/or NEC rated wire for cable trays. These less flammable cables decrease the overall fuel loading and loss potential in the tunnel, making the need for sprinkler protection in the tunnel unnecessary.

6.2 Housekeeping in Vital Areas

For this high value facility, good housekeeping and control of combustibles is achieved. The experimental process screens beam line activities for compliance with this goal. The NSRL self-inspection program (Tier I) monitors routine experimental aspects. The BNL Plan Review Process screens conventional construction operations.

6.3 Building Materials

No significant amounts of exposed polystyrene insulation or other highly combustible building materials are used in the construction or operations at the NSRL. Therefore, no special fire protection precautions, beyond those that are generically described in this section, are required for this facility.

6.4 Exterior Exposure Hazards

Any structure, area or piece of equipment that is subject to harmful effects from, or can cause harmful effects to; this facility is defined as a exterior exposure. Exterior exposures can be categorized as: elements outside of the facility, and as components of the facility.

6.4.1 Elements Outside of the Facility

The following is a summary of fire exposures to the NSRL facility.

North: Structures are over 150 feet distant from the facility. This is a minor fire exposure.

South: Structures are over 150 feet distant from the facility. This is a minor fire exposure.

East : Tree line is over 100 feet distant from the facility. This is a minor fire exposure.

West: Structures are over 150 feet distant from the facility. This is a minor fire exposure

6.4.2 Components of the Facility

The cooling tower does not pose a fire exposure to the complex, as previously described in section 5.1.4. The electrical substation to the west of Bldg. 957 does not pose a fire exposure to the complex, as previously described in section 5.1.5.

6.5 Natural Hazard Exposure

Natural Hazards can be classified in five hazard categories: lightning, windstorm, wild fire, earthquake and flooding. The following is an evaluation for each category.

6.5.1 Lightning Potential

Lightning damage potential of the Target Room (956) and the BAF Tunnel is zero for these two underground facilities.

The lightning damage potential for the NSRL Support building (958) and the NSRL Power Supply building (957) is a concern based on NFPA 780 Appendix H "*Lightning Risk Assessment* "calculation. Following the Risk Assessment methodology as shown in appendix A the expected lightning frequency ($\mathbf{N_d}$) is greater than the tolerable lightning frequency ($\mathbf{N_c}$). NFPA 780 recommends when ($\mathbf{N_d}$) **>** ($\mathbf{N_c}$) that a lightning protection system should be installed. (Recommendation 4)

The lightning damage potential for this facility is not a concern based on NFPA 780 Appendix H "*Lightning Risk Assessment* "calculation. Following the Risk Assessment methodology as shown in appendix A the expected lightning frequency ($\mathbf{N_d}$) is less than the tolerable lightning frequency ($\mathbf{N_c}$). NFPA 780 recommends when ($\mathbf{N_d}$) **≤** ($\mathbf{N_c}$) that a lightning protection system is optional.

6.5.2 Windstorm Potential

There are no windstorm concerns with the underground Target Room and the Tunnel.

Buildings 957 and 958 have 22 gauge steel, 16 inch wide by 2 inch high standing seam roof panels. The roof panels are UL 580 (Standard *for Uplift Resistance of Roof assemblies*) classified as "Class 90" rated assemblies. R-30 rated 8 inch thick fiberglass insulation is attached to the underside of the roofs. The conditions of the roofs appear to be in good condition. Windstorm potential is a minimal concern for these buildings.

6.5.3 Brush Fire Potential

The NSRL is located in the northern part of BNL and borders the Pine Barrens wild lands. Pine trees and shrubs do not pose a potential exposure to the insulated metal structures. Established roadways provided engineered features that help protect the facility from a potential wild land fire. The roof systems will not ignite from burning brand produced in a brush fire. .

6.5.4 Earthquake Potential

The seismic damage potential for this facility is classified as low based on a Natural Hazards analysis produced for the BNL campus titled "*DOE Accelerator Order 5480.25 Implementation Plane for Brookhaven National Laboratory National Phenomena Hazards Evaluation*" dated April 1994.

6.5.5 Flooding Potential

The ground around the site is graded away from the buildings. The flooding potential for this facility is classified as low based on a Natural Hazards analysis produced for the BNL campus titled "*DOE Accelerator Order 5480.25 Implementation Plane for Brookhaven National Laboratory National Phenomena Hazards Evaluation*" dated April 1994.

6.5.6 Environmental clean-up costs

Toxic, biological, and radiation incidents resulting from a fire, including water runoff, are analyzed in sections 6.5.4.1 through 6.5.4.3, below.

6.6 Toxic Fire Potential

There are no known materials in the NSRL that, if involved in a fire, would result in a significant quantity of toxic material being created and released.

6.7 Biological Fire Potential

There are no known materials in the NASA Space Radiation Laboratory that, if involved in a fire, would result in a significant quantity of toxic material being created and released.
BNL has an Institutional Bio-Safety Review committee which reviews materials of this type. The NSRL experimental review committee would pass these experimental requests to them. While biological matter has been used and will be used in the laboratory spaces of the NSRL, the hazard is low. There are no aggressive organisms within the current programs of the NSRL (only BSL II, no BSL III or IV). Other than pre-fire planning information, there is no fire issues related to biological organism at the NSRL.

6.8 Radiation Fire Potential

By the nature of the operations of the accelerator, various pieces of equipment can become activated. Since this is an electron accelerator, any levels are low. This activation is not expected to pose a significant environmental impact in the event of a fire since the material will not be easily disbursed. No other radioactive materials are used or stored in the NSRL.

7 PRE-FIRE AND EMERGENCY PLANNING

The BNL Fire Department maintains an adequate pre-fire plan book for this facility (http://intranet.bnl.gov/emergencyservices/runcards/main_i.asp).
A Local Emergency Plan is maintained for the NASA Space Radiation Laboratory Complex. It includes Control Room Operator actions to take with various alarms. Operator requirements are documented in NSRL procedures.

7.1 Protection of Essential Safety Class Systems

There is no essential safety class systems associated with this non-nuclear facility.

7.2 Protection of Vital Programs

The operations associated with this facility are not considered to be a DOE vital program. Therefore, no special fire protection precautions, beyond those that are generically described above, are required for this facility.

7.3 Protection of High Value Property

The majority of the dollar value is concentrated in the dos. These areas are valued below $25 Million and loss potentials are acceptable for these area

7.4 Critical Process Equipment

The following tables list the systems that will be present in the facilities, their values (including development costs) and their expected replacement values (without salvage). The costs reflect the pervious estimated costs table in the 2001 Fire Hazard Analysis.

Location	System	Initial Cost	Replacement Cost (Material & labor, less engineering)
6.4.1 BAF Tunnel			
	Magnets	$470,000	$115,000
	Instrumentation	$750,000	$365,000
	Vacuum	$645,000	$305,000
	Sub Total:	$1,865,000	$785,000
6.4.2 Building 956			
	Dosimetry	$1,000,000	$250,000
	Sub Total:	$1,000,000	$250,000
6.4.3 Building 957			
	Power Supplies	$850,000	$550,000
	Instrumentation	$750,000	$200,000
	Vacuum	$200,000	$100,000
	Pump Room Equipment	$420,000	$100,000
	Sub Total:	$2,220,000	$950,000
6.4.4 Building 958			
	Dosimeter Room	$1,400,000	$600,000
	Instrumentation	$750,000	$200,000
	Laboratory Equipment	$278,000	$206,000
	Sub Total:	$2,428,000	$1,006,000
	Total:	**$7,513,000**	**$2,991,000**

7.5 The Maximum Possible Fire Loss (MPFL)

There are two fire creation scenarios that represent the maximum possible fire loss: non-arson MPFL and arson MPFL. MPFL estimates are based on a fire in which active fire suppression systems fails (sprinklers, detection, fire alarm). The following details the expect loss under both scenarios.

7.5.1 Non-Arson MPFL

In this scenario the worst case in all the buildings would be a electrical fire started in a instrumentation cabinet in “B” Lab room. The fire remains undetected for a long period of time. The delay of notification to the fire department allows the fire to migrate into the ceiling and involve the contents on the ladder racks and within the ceiling to heat up and contribute to the spread of fire and smoke into adjacent spaces. Fire and smoke damage is moderate to the area around The “B” Lab room. Smoke damage to the Target Room (956) is minor. Salvageable amount of the building contents is considered high.

Maximum Possible Fire Loss (MPFL) for this scenario is estimated to be in excess of $1.1 million. The MPFL of this scenario is less than the requirement of installing fire

barriers to limit the damage the facility if it exceeded the $25 million threshold mandated by DOE. The following is the detail behind the non-arson MPFL estimate.

Non-Arson MPFL Calculation Summary

6.5.1 Replacement cost of construction, building systems & contents	$	1,000,000
6.5.2 Cost of upgrades due to code changes required for new construction		
6.5.3 Cost of lost time	$	85,000
6.5.4 Environmental clean-up costs	$	-
6.5.5 Exposure damage to other buildings, structures and property	$	-
6.5.6 Liability damages	$	-
TOTAL	**$**	**1,085,000**

7.5.1.1 Replacement cost of building and building systems

The initial cost to construct the NSRL Support building was roughly $1, 000,000 in 1998. The foundation and engineering costs will be estimated as equal to 10% of the total cost. The costs to replace the building will be estimated using an inflation rate of 4% for each year between initial construction (1998) and 2004. Therefore in today's costs the replacement valve will be 126% of original cost.

7.5.1.2 Cost of upgrades due to code changes

The cost to upgrade the building to current codes is estimated to be minimal. For this calculation we will assume no cost for upgrades.

7.5.1.3 Cost of lost time

Assuming a experiment month lost during rebuilding and commissioning the damaged area. The cost for that year will be about $85,000

7.5.1.4 Environmental clean-up costs

Toxic, biological, and radiation incidents resulting from a fire, including water runoff were deem to be minimal in sections 5.6 through 5.8 above. For this calculation we will assume no cost.

7.5.1.5 Exposure damage to other buildings, structures and property

As described in section 5.3.1 above the exposure potential to other buildings, structures and property is negligible. For this calculation we will assume no cost.

7.5.1.6 Liability damages

Liability damage is defined as the costs associated with the effect of exposures

7.5.2 Arson MPFL

In this scenario the worst case in all the buildings would be an arsonist using a flammable liquid to create a large fire in the building. The fire remains undetected for a long period of time. The delay of notification to the fire department allows the fire to migrate into the ceiling and involve the contents on the ladder racks and within the ceiling to heat up and contribute to the spread of fire and smoke into adjacent spaces. Fire and smoke damage is moderate to the entire Building. Smoke damage to the Target Room (956) is moderate. Salvageable amount of the building contents is considered minimal.

Maximum Possible Fire Loss (MPFL) for this scenario is estimated to be in excess of $4 million. While the MPFL of this scenario is less than the requirement of installing fire barriers to limit the damage the facility if it exceeded the $25 million threshold mandated by DOE. The following is the detail behind the arson MPFL estimate.

Arson MPFL Calculation Summary

6.5.1 Replacement cost of construction, building systems & contents	$	3,000,000
6.5.2 Cost of upgrades due to code changes required for new construction	$	20,000
6.5.3 Cost of lost time	$	1,000,000
6.5.4 Environmental clean-up costs	$	-
6.5.5 Exposure damage to other buildings, structures and property	$	-
6.5.6 Liability damages	$	-
TOTAL	**$**	**4,020,000**

7.5.2.1 Replacement cost of building and building systems

The initial cost to construct the NSRL Support building was roughly $1, 000,000 in 1998. The foundation and engineering costs will be estimated as equal to 10% of the total cost. The costs to replace the building will be estimated using an inflation rate of 4% for each year between initial construction (1998) and 2004. Therefore in today's costs the replacement valve will be 126% of original cost.

7.5.2.2 Cost of upgrades due to code changes

The cost to upgrade the building to current codes is estimated to be minimal. The only upgrade would be the one hour rated occupancy separation requirement between the NSRL Support building and the Target Room. For this calculation we will assume $20,000 for upgrades.

7.5.2.3 Cost of lost time

Assuming a experiment year lost during rebuilding and commissioning the lost facility. The cost for that year will be about $1,000,000

7.5.2.4 Environmental clean-up costs

Toxic, biological, and radiation incidents resulting from a fire, including water runoff were deem to be minimal in sections 5.6 through 5.8 above. For this calculation we will assume no cost.

7.5.2.5 Exposure damage to other buildings, structures and property

As described in section 5.3.1 above the exposure potential to other buildings, structures and property is negligible. For this calculation we will assume no cost.

7.5.2.6 Liability damages

Liability damage is defined as the costs associated with the effect of exposures

7.6 Recovery potential

Within the facilities of the NASA Space Radiation Laboratory, critical process parts have been identified by the Department. Critical process parts are those items essential to the operations of the accelerator that require a long lead-time for replacement. These spares are stored in a separate building, not subject to a common incident

7.7 BNL Fire/Rescue Group

The BNL Fire/Rescue Group is a full time, paid department. Minimum staffing is five firefighters and one officer per shift. The firefighters are trained to meet Firefighter Level III by International Fire Service Training Association standard, National Fire Protection Association (NFPA) Fire Fighter Level II standard, and (NFPA) Hazardous Material Technician Level and they are Suffolk County Certified Confined Space Rescuers.

The BNL Fire/Rescue Group also provides emergency medical services to an on-site population of 3200 people. Minimums of two members per shift hold New York State "Emergency Medical Technician - D" certifications ("D" is for defibrillation). Normally all five firefighters have EMT status. The Group operates a New York State Certified Basic Life Support ambulance. Medivac services are available to BNL via the Suffolk County Police Department. Additionally the Fire/Rescue Group has two 1500 GPM. "Class A" Pumpers, one Rescue Vehicle for initial hazardous material incident response and heavy rescue operation, and one Incident Command Vehicle.

The single Fire Station is located on the west side of the BNL Site. Response time to the most remote section of the BNL Site is less than eight minutes. Response time to the NASA Space Radiation Laboratory is estimated at 5 minutes.

BNL participates in the Suffolk County Mutual Aid Agreement. This allows the resources from over 130 departments to assist BNL. BNL is also a member of the Town of Brookhaven Foam Bank. BNL has a mutual aid agreement for hazardous material incidents with the Town of Brookhaven and Stonybrook University.

7.8 Fire Apparatus Accessibility

Fire apparatus accessibility is adequate for the facility. Current parking lot configurations allow access by apparatus in the event of an emergency.

7.9 Security Considerations Related to Fire Protection

The facility will have security measures to restrict access, including the use of card readers and iris scanners. Provisions will be made for Fire/Rescue access via card reader programming, provision of master key, or installation of interlocked crash doors. Ingress includes interlocked crash panels in the doors to allow emergency entry.

8 LIFE SAFETY CONSIDERATIONS

Major life safety considerations for this facility include the following components; means of egress components and capacity, number and arrangement of the means of egress, travel distances to exits, discharge from the exits, and emergency lighting and marking of the means of egress.

This buildings was constructed to comply with the latest version of the National Life Safety Code NFPA 101 at the time of construction. DOE now requires all building to conform to local building codes and NFPA 101. The requirements of the 2002 edition of the New York State Building Code (BCNYS) and the 2003 edition of the National Life Safety Code (NFPA 101), will be presented in the Fire Hazard Analysis.

8.1 Occupancy classification

The NSRL Target Room (956), BAF Tunnel, and Power Supply Building 957 are classified by BCNYS (Sec. 306.1) as "*Factory Industrial F-2 Low Hazard*" occupancy." NFPA 101 (3.3.152.8.3) classifies these buildings as "*Industrial, Special Purpose*" occupancy.

NSRL Support Building (958) is classified by BCNYS (Sec. 306.1) as "*Business*" occupancy. NFPA 101 (3.3.152.8.1) classifies this building as "*Industrial, General Purpose*" occupancy.

8.2 Occupancy load factor and calculations

For the NSRL Target Room (956), BAF Tunnel, and Power Supply Building 957 the BCNYS (Table 1003.2.2.2) occupancy load factor is 100 sq. ft. gross per occupant. The NFPA 101 occupancy load factor for these buildings is zero. NFPA 101 (Table 7.3.1.2) states that "*Special Purpose Industrial Use*" load factor calculation is not applicable.

For the NSRL Support Building (958) the BCNYS (Table 1003.2.2.2) occupancy load factor is 100 sq. ft. gross per occupant. The NFPA 101 (Table 7.3.1.2) occupancy load factor for this building is 100 sq. ft. gross per occupant.

NSRL Target Room (956) has a gross area of 4830 square feet. Per the BCNYS the calculated occupant load for this building is 49 occupants. Based on NFPA 101, the occupant load calculation for this building is considered to be zero on both levels.

Power Supply Building 957 has a gross area of 2,600 square feet per level. Per the BCNYS the calculated occupant load for Building 957 is 26 for the ground floor and 26 for the mezzanine level. Based on NFPA 101, the occupant load calculation for this building is considered to be zero on both levels.

Building 958 has a gross area of 4,554 square feet. Per the BCNYS the calculated occupant load for this building is 46 occupants. Based on NFPA 101 the occupant load calculation result for the building is 46 occupants.

8.3 Means of Egress

The means of egress for the four buildings meet the present code requirements for number and arrangement of exits, capacity of exits, travel distance, common path of travel, dead ends, and security considerations related to egress. The following subsections provide the egress detail for each of the buildings.

8.3.1 Number and Arrangement of Exits

NSRL Target Room (956) has two 36 inch clear width doors leading out of the area. One exit leads to the BAF Tunnel and the other one to NSRL Support Building (958).

BAF Tunnel has two 36 inch clear width doors leading out of the area. One exit leads to the NSRL Target Room (956) and the other one to the parking lot south of the Power Supply Building 957.

Power Supply Building 957 has three 36 inch clear width doors leading to the outside on the ground floor. There are two means of egress on the mezzanine level. A 44 inch

clear width open stair leads to the ground floor on the south-central side of the building, and a fixed fire escape ladder on the northwest side leads down to the ground floor. There are not code issues with regard to the ladder. NFPA 101 (7.2.9.1(4)) allows a fire escape ladder for "*Industrial* - Special *Purpose*" occupancy provided it is a secondary means of egress subject to occupancy not to exceed three persons who are capable of using the ladder. The ladder is not recognized by the BCNYS as a means of exit. However, BCNYS (Table 1004.2.1) allows "Factory *Industrial F-1 Moderate Hazard"* occupancies to have only one means of egress provided the occupancy load less than 50.

NSRL Support Building (958) has four 36 inch clear width doors leading out of the area. One exit leads to the NSRL Target Room (956) and the other three lead to the parking lot west of the building. Exit separation

8.3.2 Capacity of Exits

NSRL Target Room (956) and the BAF Tunnel exit capacity exceeds the occupant loading based on the BCNYS (Table 1003.2.3) and NFPA 101 (Table 7.3.3.1) for stairways and other egress components in a non sprinklered facility.

Power Supply Building (957) exit capacity exceeds the occupant loading on both the ground and mezzanine levels based on the BCNYS (Table 1003.2.3) and NFPA 101 (Table 7.3.3.1) for stairways and other egress components in a non sprinklered facility.

NSRL Support Building (958) exit capacity exceeds the occupant loading on both the ground and mezzanine levels based on the BCNYS (Table 1003.2.3) and NFPA 101 (Table 7.3.3.1) for stairways and other egress components in a sprinklered facility.

8.3.3 Travel Distance

NSRL Target Room (956), BAF Tunnel, and the Power Supply Building (957) egress paths do not exceed the BCNYS and NFPA 101 travel distance limitations. BCNYS (Table 1004.2.4) limits egress travel distance to 300 feet in this type of non-sprinklered occupancy. NFPA 101 (Table 40.2.6) limits egress travel distance to 400 feet in this type of non-sprinklered occupancy.

NSRL Support Building (958) egress paths do not exceed the BCNYS and NFPA 101 travel distance limitations. BCNYS (Table 1004.2.4) limits egress travel distance to 400 feet in this type of sprinklered occupancy. NFPA 101 (Table 40.2.6) limits egress travel distance to 250 feet in this type of sprinklered occupancy.

8.3.4 Common Path of Travel

NSRL Target Room (956) and the BAF Tunnel do have common path of travel issues as defined by BCNYS and NFPA 101.

Power Supply Building (957) does not exceed the common path of travel distance limits of BCNYS and NFPA 101. The only common path of travel distance is on the mezzanine level and the distance is 45 feet. NFPA 101 "Table 40.2.5" limits common path of travel distance to 50 feet in this type of non-sprinklered occupancy. BCNYS (1004.2.5) limits

common path of travel distance to 75 feet in this type of non-sprinklered occupancy.

NSRL Support Building (958) does not exceed the common path of travel distance limits of BCNYS and NFPA 101. The longest common path of travel distance is in the “C” lab area and the distance is 50 feet. BCNYS (1004.2.5(1)) and NFPA 101 (Table 40.2.5) limits common path of travel distance to 100 feet in this type of sprinklered occupancy.

8.3.5 Dead Ends

In the NSRL Target Room (956) and Power Supply Building (957) there are no dead end corridor issues as defined by NFPA 101.

The BAF Tunnel’s dead end corridor does not exceed the distance limitation of NFPA 101 and BCNYS. The 45 foot dead end condition in the south end of the BAF Tunnel is less than the 50 foot limit defined by NFPA 101 (Table 40.2.5) and the Fire Code of New York State (FCNYS) (Table 1010.17.2) in this type of non-sprinklered occupancy.

NSRL Support Building (958) dead end corridor does not exceed the distance limitation of NFPA 101 and BCNYS. The longest dead end corridor condition is on the north side of the building by the gowning area. The 10 foot dead end condition is less than the 50 foot limit defined by NFPA 101 (Table 40.2.5) and the Fire Code of New York State (FCNYS) (Table 1010.17.2) in this type of sprinklered occupancy.

8.3.6 Security Considerations Related to Fire Protection

The BAF Tunnel Radiation security barrier exterior door has measures to restrict access, including card readers and an iris scanner. Provisions were made for Fire/Rescue to gain emergency access to the Tunnel by the installation of interlocked crash panels.

Between NSRL Target Room (956) and the NSRL Support Building (958) is a Radiation security barrier door. The door has measures to restrict access into the Target Room, including card readers and an iris scanner. In an emergency, the door can be opened by the interlocked crash panels.

NSRL Support Building (958) and Power Supply Building (957) do not have special access controls to restrict egress or ingress.

8.4 Barriers

8.4.1 Occupancy Separations

BAF Tunnel and Power Supply Building (957) meets the requirements for occupancy separation as defined by the BCNYS (Table 302.3) and NFPA 101 (Table 6.1.14.4.1.) There are no areas in these facilities that are defined as incidental or accessory occupancy use areas as noted in BCNYS “302.1.1” or NFPA 101 “6.1.14.1.2” and “6.1.14.1.3.”

NSRL Target Room (956) complies with the codes of record with respect to occupancy separations. There are no areas in these facilities that are defined as incidental or accessory occupancy use areas as noted in BCNYS “302.1.1” or NFPA 101 “6.1.14.1.2” and “6.1.14.1.3.” The building does not have the one hour rated occupancy separation

requirement now mandated by the latest editions of the BCNYS and NFPA 101 between the Target Room (956) and the NSRL Support Building (958). Compliance with the new requirements would be required only in the case of a change of occupancy or egress path, or major renovation work in either building.

NSRL Support Building (958) complies with the codes of record with respect to occupancy separations. There are no areas in these facilities that are defined as incidental or accessory occupancy use areas as noted in BCNYS “302.1.1” or NFPA 101 “6.1.14.1.2” and “6.1.14.1.3.” The building does not have the one hour rated occupancy separation requirement now mandated by the latest editions of the BCNYS and NFPA 101 between the Target Room (956) and the NSRL Support Building (958). Compliance with the new requirements would be required only in the case of a change of occupancy or egress path, or major renovation work in either building.

8.4.2 Separation of Means of Egress

NSRL Target Room (956)and the BAF Tunnel complies with separations of means of egress as defined by the BCNYS (Table 1005.3.3) and NFPA 101 (7.1.3.1) do Corridors used for egress are not required to be rated due to the building being fully sprinklered per BCNYS and NFPA 101

8.4.3 Vertical Opening Barriers

Vertical opening which would require BCNYS and NFPA 101 rated barriers do not exist in the buildings.

8.5 Exit Signs and Emergency lighting

Placement of exit signs in all the buildings meets NFPA 101 and BCNYS “1003.2.10.” Illumination of exit signs meets NFPA 101 “40.2.8” and BCNYS “1003.2.10.4.

Emergency lighting of all means of egress is provided in the building by florescent light fixtures wired to the emergency power system. Emergency lighting of all means of egress is required by BCNYS “1003.2.11” and NFPA 101 “40.2.8.”

8.6 Fire Protection Systems Required By Code

There is no additional fire protection system requirements above the present fire protection systems installed in the buildings.

8.7 Operational Requirements That Are Required By Code

There are no additional operational requirements required by code.

Appendix A – Lightning Risk Calculation

Building 957

EXPECTED LIGHTNING STROKE FREQUENCY FROM NFPA 780 APPENDIX H

$$N_d = (N_g)(A_e)(C_1)$$

N_d = **0.0019** = yearly average flash density in the region where the structure is located

(N_g) = **2.0** = the yearly lightning strike frequency to the structure

(C_1) = **0.25** = the environmental coefficient

(A_e) = **0.00375546** = the equivalent collective area of the structure in km2 from calculation below

Length (L)	**66**	Feet
Width (W)	**40**	Feet
Height (H)	**27**	Feet

Figure H.4.2(a) Results 0.00375546 sq. km

Figure H.4.2(b) Results 0.00191486 sq. km

Table H.4.3 Determination of Environmental Coefficient C_1

Relative Structure Location	C_1
Structure located within a space containing structures or trees of the same height or taller within a distance of $3H$	0.25
Structure surrounded by smaller structures within a distance of $3H$	0.5
Isolated structure, no other structures located within a distance of $3H$	1
Isolated structure on a hilltop	2

Assume

0.5

Figure H.4.2(a) Calculation of the equivalent collective area for a rectangular structure.

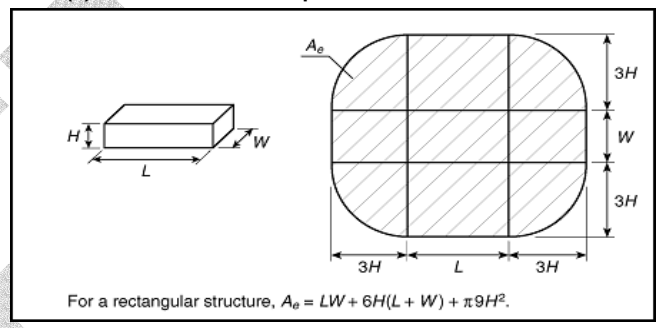
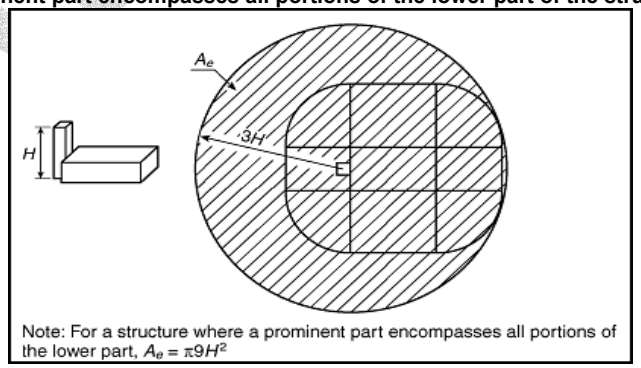


Figure H.4.2(b) Calculation of the equivalent collective area for a structure where a prominent part encompasses all portions of the lower part of the structure.



= input required

Building 957 cont.

$$N_c = \frac{1.5 \times 10^{-3}}{C}$$

where $C = (C_2)(C_3)(C_4)(C_5)$.

N_c = **0.0012**

Assume **0.5**

C_2 — Structural Coefficients			
	Roof		
Structure	**Metal**	**Nonmetallic**	**Flammable**
Metal	0.5	1.0	2.0
Nonmetallic	1.0	1.0	2.5
Flammable	2.0	2.5	3.0

Assume **1.0**

Structure Contents	C_3
Low value and nonflammable	0.5
Standard value and nonflammable	1.0
High value, moderate flammability	2.0
Exceptional value, flammable, computer or electronics	3.0
Exceptional value, irreplaceable cultural items	4.0

Assume **0.5**

Structure Occupancy	C_4
Unoccupied	0.5
Normally Occupied	1.0
Difficult to evacuate or risk of panic	3.0

Assume **5.0**

Lightning Consequence	C_5
Continuity of facility services not required, no environmental impact	1.0
Continuity of facility services required, no environmental impact	5.0
Consequences to the environment	10.0

= input required

Building 958

$$N_d = (N_g)(A_e)(C_1)$$

N_d = **0.0056** = yearly average flash density in the region where the structure is located

(N_g) = **2.0** = the yearly lightning strike frequency to the structure

(C_1) = **1.00** = the environmental coefficient

(A_e) = **0.00279644** = the equivalent collective area of the structure in km2 from calculation below

Length (L)	**48**	Feet
Width (W)	**101**	Feet
Height (H)	**18**	Feet

Figure H.4.2(a) Results 0.00279644 sq. km

Figure H.4.2(b) Results 0.00085105 sq. km

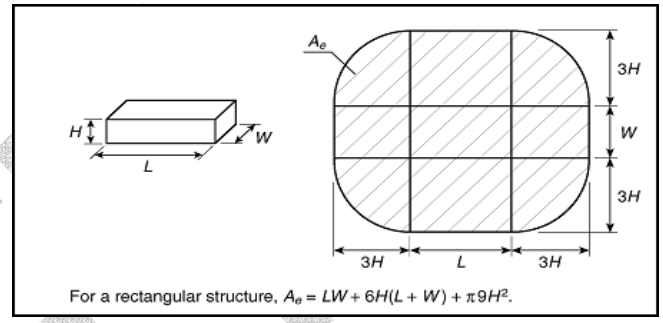
Table H.4.3 Determination of Environmental Coefficient C_1

Relative Structure Location	C_1
Structure located within a space containing structures or trees of the same height or taller within a distance of $3H$	0.25
Structure surrounded by smaller structures within a distance of $3H$	0.5
Isolated structure, no other structures located within a distance of $3H$	1
Isolated structure on a hilltop	2

Assume

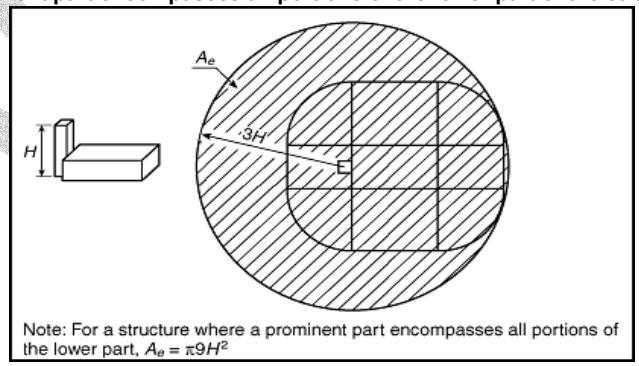
1.0

Figure H.4.2(a) Calculation of the equivalent collective area for a rectangular structure.



For a rectangular structure, $A_e = LW + 6H(L + W) + \pi 9H^2$.

Figure H.4.2(b) Calculation of the equivalent collective area for a structure where a prominent part encompasses all portions of the lower part of the structure.



Note: For a structure where a prominent part encompasses all portions of the lower part, $A_e = \pi 9H^2$

= input required

Building 958 cont.

TOLERABLE LIGHTNING FREQUENCY FROM NFPA 780 APPENDIX H

N_c = **0.0012**

$$N_c = \frac{1.5 \times 10^{-3}}{C}$$

where $C = (C_2)(C_3)(C_4)(C_5)$.

Assume **0.5**

C_2 — Structural Coefficients			
	Roof		
Structure	Metal	Nonmetallic	Flammable
Metal	0.5	1.0	2.0
Nonmetallic	1.0	1.0	2.5
Flammable	2.0	2.5	3.0

Assume **1.0**

Structure Contents	C_3
Low value and nonflammable	0.5
Standard value and nonflammable	1.0
High value, moderate flammability	2.0
Exceptional value, flammable, computer or electronics	3.0
Exceptional value, irreplaceable cultural items	4.0

Assume **0.5**

Structure Occupancy	C_4
Unoccupied	0.5
Normally Occupied	1.0
Difficult to evacuate or risk of panic	3.0

Assume **5.0**

Lightning Consequence	C_5
Continuity of facility services not required, no environmental impact	1.0
Continuity of facility services required, no environmental impact	5.0
Consequences to the environment	10.0

= input required